Tampa Bay NEP Research Plan: A Decision Science Perspective on Understanding Public Values and Attitudes Related to Ecological Risk Management

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Table of Contents

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1.0 Project summary

The purpose of this research plan is to outline an approach to understanding public values and attitudes relating to policy initiatives in ecological risk management. Although key elements of the approach are intended to be broadly applicable, the specific case study of nitrogen deposition by air to the Tampa Bay, Florida estuary is used to illustrate and provide supplementary details of the proposed approach. Understanding how the public views the problem of airborne nitrogen deposition, and what considerations it may use when evaluating alternative policy responses, is one of the primary questions now under study by the Tampa Bay National Estuary Program (TBNEP). In particular, the TBNEP seeks answers to questions concerning (a) the reasons why people care about protection of water quality in the Tampa Bay estuary, and (b) ways in which the broad range of stakeholder concerns can be evaluated and measured to facilitate their incorporation into risk-management policies.

This research plan focuses on the contribution of insights from the decision sciences to addressing these important questions. It represents one of four social science perspectives (the others being psychology, anthropology, and innovative economics) to understanding public values, which taken as a whole seek to broaden the range of techniques available to encourage public input and to develop an improved management plan for the estuary. In many respects the four approaches are complementary, so that both general techniques and specific study suggestions are expected to be quite similar. In other respects, however, the four approaches are quite different, with a decision science perspective giving particular attention to the ways in which values and tradeoffs are formed, to the quality and interpretation of expressed judgments and evaluations, and to the use of decision aids in clarifying stakeholder concerns and in developing defensible linkages between the value- and fact-based aspects of a proposed risk-management initiative. In light of the mandate for the research plan, this discussion of a proposed study approach will focus on insights and techniques that are based in the decision sciences and leave issues relating to the complementarity of the different approaches to presentations at the May, 2001 workshop and to subsequent discussions.

A variety of techniques from the decision sciences can assist the Tampa Bay NEP in developing plans for protection of the estuary that incorporate, and are responsive to, both the complexities of the ecological risk-management challenges and the interests and values of the diverse set of stakeholders. Although implementation of the selected techniques would provide immediate insights, many of their benefits will become even more apparent over time, as the TBNEP moves on to the consideration of more costly and more controversial protection measures. Five principal types of benefits are foreseen.

A. <u>Nurturing collaborative exchanges.</u> Dialogue, both within and across stakeholder groups, has been and will continue to be an important reason for the success of the TBNEP. At Tampa Bay, open discussions need to occur among many different parties: between technical experts and laypersons, between natural and social scientists, between federal and state and local government employees, and among representatives of varying perspectives and opinions. The value-based approaches described in this research plan both foster and focus dialogue, whereas techniques for decomposing complex problems and addressing uncertainties will help to ensure that open dialogue also occurs among technical experts.

B. <u>Implementing structured decision-making processes</u>. Structured processes are essential for understanding the diversity of values and concerns that characterize different stakeholders and for using this information to create the best possible alternatives (in the form of recommended actions). Because they establish an open and transparent decision process, structured methods for involving stakeholders also provide a highly defensible mechanism for making policy choices, one that is viewed as legitimate because the steps are clearly delineated and because components of recommendations can easily be traced back to stakeholder expressions of value.

C. <u>Clarifying sources of scientific uncertainty</u>. Scientific uncertainty is unavoidable in programs such as the TBNEP, and over the next decade or two it is likely to increase as the Program's focus moves from land-based and point-source to airborne and farfield sources of nitrogen deposition. As a result, it is important to clarify differing perspectives among scientists and to attempt to understand the reasons for these differences, in terms of identifying the best actions for protecting the estuary and in terms of maintaining strong public support.

D. <u>Learning over time</u>. Developing management structures that can incorporate learning over time is fundamental to the long-run success of a program such as the TBNEP. Some of this learning will come in the form of staying in tune with the changing values of the residents of Tampa Bay. In addition, adaptive management processes are likely to form an increasingly important part of the TBNEP, because of the help they provide in establishing flexible management responses to reducing uncertainty that incorporate learning over time and, by carefully monitoring effects, reduce both the probability and expected cost of failures.

E. Improving the quality of communication. Communication up to this point in time has been relatively straightforward because the benefits of actions undertaken by the TBNEP have been widely supported and highly visible whereas the costs have been low. As the costs rise over time and the benefits become less salient, it will be important for the TBNEP to continue to communicate effectively with its diverse group of stakeholders; this is likely to also become more difficult because the geographic area affected by TBNEP programs will become larger. Different strategies will be called for depending on whether the communication is about values or about facts; either way, an interactive, two-way communication process is recommended.

The past success of the TBNEP program appears to have created excellent conditions and motivation for undertaking a deeper look at both the values of stakeholders and the underlying science. Techniques from the decision sciences can be used proactively to learn more about the relationships among stakeholder concerns, the reasons for conflict among scientists, and the types of decision processes that will be viewed as continuing to create defensible, legitimate recommendations. The visible success of the program to date has created an unusual and welcome window of opportunity, one that should be embraced soon in anticipation of the more difficult tradeoffs, and less visible benefits, that are likely to come in the years ahead.

2.0 Problem background: Understanding the context for estuary protection

Tampa Bay is one of 28 sites selected for the National Estuary Program (NEP), which is administered by the Environmental Protection Agency (EPA) with the goal of providing technical assistance and supplementary federal funding to initiate a voluntary estuary management plan. Tampa Bay is the largest open-water estuary in Florida (approximately 400 square miles), with inflows from four major rivers and 40 smaller streams. Three classes of wetlands (salt marshes, mangrove forests, and salt barrens) provide habitat for a wide range of plants and animals and form an essential part of the region’s natural drainage and filtering system. The subtropical climate of the area has led to rapid growth, with the current population of more than two million people projected to increase by 15-20% over the next decade.

The Tampa Bay National Estuary Program (TBNEP) began in 1991 with a focus on developing and implementing an agreement among local participants that would result in a management plan to improve water quality and living resources in the Tampa Bay estuary. A Comprehensive

Conservation and Management Plan (CCMP) was finalized in December, 1996 with input from, and the support of, a broad range of local participants. This CCMP outlined a management and monitoring plan that included “binding commitments for nutrient reductions and habitat restoration” that would be revisited every five years by local participants as part of an innovative Interlocal Agreement (Imperial, 2000). In particular, the plan has focused on reductions in nitrogen emissions to the Bay, recognizing that lower nitrogen levels in turn lead to less algae growth in the water. The plan essentially proposes a menu of actions, built on eleven primary goals of the TBNEP relating to improving water and sediment quality, living resources, and related land uses.

Thus far, strong support has existed for the TBNEP initiatives and the program is widely considered a success. There are many explanations for this broad-based support, with a primary reason being the attention given by the TBNEP staff and consultants over the past decade to the development of close working relationships with a variety of local industry, regulatory agency, and government partners. Other reasons for the success of the first five years (1996-2000) of the TBNEP include:

1) a history of cleanup efforts in Tampa Bay going back to at least the late 1970s, when local upgrades in sewage treatment plants and new wastewater reuse programs combined with state-sponsored nonpollution abatement initiatives to reverse the historic downward trends in water quality of the 1950s and 1960s;

2) the relatively straightforward science associated with point-source cleanup options: technologies and costs for upgrading wastewater treatment plants, re-using wastewater, or minimizing storm water impacts from new development were all well understood;

3) the widespread use of the Tampa Bay resource base: many people in the region drive over one of several bridges every day, there are many swimmers and boaters, and improvements in ecological resources such as seagrass, fish, and birds are highly visible;

4) the visible success of these earlier water-quality improvements, with reductions in nitrogen loadings to Tampa Bay resulting in “dramatic improvements in water clarity and reductions in algae biomass” (Imperial, 2000); and

5) the shared institutional incentives and responsibility for cleanup; for example, all counties within the region face onto the Bay, and many of the private contributors to pollution (e.g., fertilizer production and runoff) were easily identified.

Many of these reasons for this early success, however, are unlikely to apply as strongly to estuary cleanup initiatives undertaken over the next decade or two: further improvements to water quality will be less dramatic visually, both the technologies and associated costs -- the underlying science and economics -- will become more uncertain, source control will become more difficult as the program shifts to a greater emphasis on airborne nitrogen deposition, and the time frame for achievement of benefits becomes longer (e.g., seagrass recovery in some areas may take 20-25 years). With recent studies showing that perhaps ½ - 3/4 of all nitrogen depositions to the Bay may come in through the air, many of these changes are expected to be reflected in the upcoming 5-year plan (scenarios for 2001-2005) that is currently under review and, even more so, in succeeding plans.

Although related goals of the TBNEP (e.g., protecting cleaner areas of the Bay from toxic contamination) will remain important, the next plans are expected to focus on farfield and vehicle emission sources of airborne nitrogen (along with additional improvements to the wastewater collection system), indicating a shift from reductions in land-based sources of nitrogen to reductions in atmospheric deposition. . Clear benefits can still be identified, but there is likely to be increasing controversy about the conclusions of the underlying science (which is only about 10 years old) and greater uncertainty about the range of proposed actions and anticipated impacts. One sign of this shift is that the Technical Advisory Committee apparently has been considering multiple management scenarios, and although it is expected to chose a mid-range conservative option that will continue to achieve Nitrogen reductions of 17 tons/yr (thereby holding the line at 92-94 levels) there is an enhanced appreciation for, and concern about, the attendant uncertainty in these estimates. We anticipate that these changes, and the need for a more complete evaluation of benefits and costs, will become even stronger in future years, with the justification for each successive five-year plan (e..g, beginning in 2006, then in 2010, then in 2015, etc.) reflecting steadily rising costs and steadily lower benefits, which in turn increases the need of the TBNEP to know how the public views its recommended actions and where strong support exists and where it doesn't.

To a large degree, therefore, the early success of the TBNEP program can be attributed in part to the preceding degradation of the region, which had the effect that many of the program's early benefits were, in essence, low-hanging fruit, relatively easy to see and inexpensive to obtain. As a result, there was little need for a detailed evaluation of actions in terms of their costs, benefits, and risks. Similarly, there was little need for an aggressive campaign to communicate the pros and cons of the TBNEP (or its predecessors), due to the high level of community support and the readily-visible nature of program benefits. However, as the attention of the TBNEP shifts to less familiar, more uncertain benefits that could impose substantially higher costs on some local governments and industries or result in restrictions on individual behaviors, more attention will need to be given to the development of appropriate actions, to the evaluation of their benefits, costs, and risks, and to the clear communication of these anticipated consequences to each of several interested parties. These are tasks ideally suited to the use of methods from the decision sciences; in large part, the discipline of the decision sciences has emerged over the past 50 years in response to problems of just this type, in which responsible policy choices need to be made in unfamiliar decision contexts that are marked by complexity (in particular, multiple players and conflicting dimensions of value), less visible ties between actions and their consequences, and greater scientific uncertainty.

3.0 Research background: Key elements of a decision science approach

This section reviews some of the key concepts from the decision sciences that have been used in earlier studies to help understand public values and attitudes toward ecological risk management initiatives. Together, they comprise a framework for helping risk managers, science experts, and community residents to jointly frame and make decisions that effectively address their goals and interests.

The starting point is one of the most robust research findings on decision making: when left to their own devices, people “systematically violate the principles of rational decision making” (Slovic, Fischhoff, & Lichtenstein, 1976). Individuals naturally respond to complex tasks by using their judgmental instincts to find an easy or adequate way through the problem at hand. People respond to probabilistic information or questions involving uncertainties with predictable biases that often ignore or incorrectly process important information (Kahneman, Slovic & Tversky, 1982).   Because these qualities -- unfamiliar and conflicting value dimensions, uncertain science, limited feedback, and diverse participants – are viewed increasingly as characteristic of Tampa Bay (and most other ecological risk-management contexts), the task of developing broadly-acceptable estuary protection actions argues strongly for decision-aiding assistance. Six elements of a decision science approach are noted as particularly relevant: each concept is briefly introduced in this section, with more detailed examples included in the next section showing how specific techniques might influence the choice of policy approaches for the Tampa Bay estuary.

3.1 Structured decision aiding

Most decision problems are poorly structured: the problem itself is ill-defined, the values of interested parties are not precisely characterized, the uncertainties are unclear, and the consequences of alternatives are not meaningfully expressed. As a result, the starting place for most decision science approaches is to carefully structure the process by which a decision is made, both descriptively (in terms of how the choice currently is understood by individuals) and prescriptively (how it would be understood if better information were available). This topic is a cornerstone of behavioral decision analysis (von Winterfeldt & Edwards, 1986) and, in turn, of multiattribute utility theory (Keeney & Raiffa, 1993). In general, a decision-aiding process should directly involve both technical (e.g., scientific) and public (e.g., community) participants in creating a framework that works through the following six tasks:

1) carefully defines the nature of the problem;
2) clearly characterizes "what matters" in the form of values or objectives, each of which is denoted in terms of a performance measure or attribute;
3) creates a broad set of attractive alternatives, responsive to these objectives;
4) employs the best available technical information to characterize impacts or consequences of the alternatives, including uncertainties;
5) identifies the tradeoffs that the alternatives entail; and
6) summarizes the areas of agreement, disagreement and reasons for those views among the stakeholders.

Values (or interests) denote what matters: the process and content considerations that together comprise what is important in the context of the specific decision problem at hand (Keeney, 1992). Value judgments, in turn, can be used to create more attractive alternatives that stand a better chance of achieving wide support, because they directly anticipate and address the concerns of the principal parties involved in the environmental dispute. Other benefits include identifying the reasons why different stakeholders disagree or agree, which (in contrast to approaches based on dispute resolution) can serve as a cornerstone of efforts to create broadly-supported actions (Gregory, McDaniels & Fields, in press). In many cases, this exercise of carefully defining values helps stakeholders to see that many values are shared even if the relative weights placed on the value dimensions (see Section 4.3) are quite different.

In the context of Tampa Bay, a structured approach to decision making would start by carefully defining the problem at hand (e.g., what is "in" or "out" of the policy context) and then eliciting the values of interested parties in some detail, emphasizing not just environmental concerns but also issues related to economics, health and safety, community development, and social considerations. The ability of alternative policies to address these diverse values would be assessed in terms of explicit performance measures, which in turn serve both to enhance the creation of new policy options and to operationalize a careful tradeoff analysis, which examines how much of one valued objective (e.g., jobs or habitat) is desirable in light of the costs it imposes on another objective (e.g., expenditures or visibility). The results of the tradeoff analysis then can be used to guide the creation and selection of preferred alternatives. Cycling iteratively through these elements, encouraging participants to express and explore their values fully and then refining the associated information on consequences until participants are satisfied they can provide well-informed judgements about which alternatives they support, is a key to successful environmental management deliberations (Gregory, Keeney, & von Winterfeldt, 1992).

3.2 Framing and context

Framing refers to the context in which a choice or judgment is made. Research has shown that different participants – the individual (or group) making the choice, the agency interested in the outcome of a vote or assessment, the media – often frame the same decision problem in different ways and that this can significantly effect how policy options are evaluated. Although framing can occur either unconsciously or consciously, in most of the situations relevant to eliciting expert and public input to environmental policies the creation of a frame is inevitable. This view suggests that stable or “true” values for many environmental resources generally do not exist but, instead, that values will be created or constructed in the course of an elicitation procedure in relation to the cues and signals that are provided (Slovic, 1995; Payne, Bettman & Johnson, 1999). Thus, attempts to avoid biasing individual perspectives in favor of the “neutral” communication of information are missing the point: if bias is to be expected, then it should be done consciously and in such a way that the individual is helped to formulate a sense of his/her own value that is well informed, has some internal validity, and is at least moderately reliable (e.g., if asked the same valuation question in two weeks, the person would answer similarly).

One of the ways in which decisions are affected by context is in terms of effects on decision processes and, in turn, the influence of several judgmental biases. As proposed by Tversky & Kahneman (1974; 1981), decision makers use “heuristics,” or simplifying rules of thumb, to arrive at judgments. Decision heuristics can be helpful, in that they reduce the time and effort needed to make judgments, but they also can lead to systematic biases in judgment. Examples include the “representativeness” heuristic, whereby the likelihood of an event is often judged in terms of how closely it resembles another supposedly similar event, and the “availability” heuristic, in which the frequency of an event is assessed in terms of the ease with which occurrences can be brought to mind. Because technical experts are just as prone to these (and other) judgmental short-cuts as are other citizens, it is important to strive to limit the influence of these heuristics on consequential decisions; as a result, decision analysts have proposed numerous tools for helping individuals to “debias” their judgments.

Another of the principle illustrations of framing is the observed difference in people's responses to a gain and to the experience of a formally equivalent loss. In most cases, the loss is felt much more acutely, so that an individual who receives (as a gain) the same amount he has lost will not feel indifferent but will have suffered a decline in well-being. This behavioral response, quite different from that predicted by conventional utility theory, is anticipated by the S-shaped value function adopted in Prospect Theory (Kahneman & Tversky, 1979), which emphasizes the significance of the reference point used to frame responses (see Figure 1).

One prediction of this disparity in responses to losses and gains is that the public will show unusually strong support for initiatives that attempt to restore prior losses; an environmental improvement action that is framed in terms of returning to an earlier, better status will be evaluated more favorably than will an otherwise identical action that is framed as an improvement from current status, with no reference to an earlier state. In the case of Tampa Bay, one implication is that surprisingly strong support will be indicated for the restoration of seagrass beds, because their return is coded as the lessening of a prior loss rather than as an improvement from current conditions.

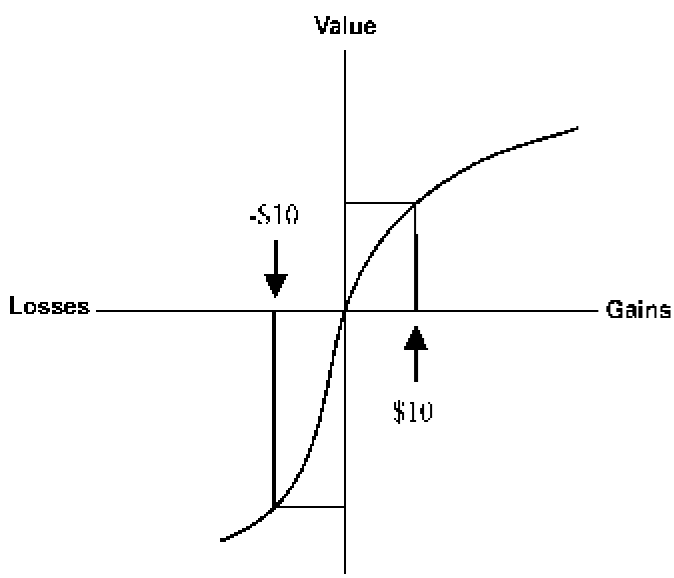


Figure 1: An example Prospect Theory value function (based on Kahneman & Tversky, 1979).

3.3 Affect and emotion

Findings in recent research on judgment and choice acknowledge the importance of affect and emotion as key elements in how individuals form judgments and make decisions. The two concepts are related but distinct: affect refers to the valence (i.e., goodness or badness) of a stimulus or to associated feeling states such as happiness or sadness, where emotions refer to the arousal (e.g, anger or excitement or outrage) experienced in relation to a stimulus. Both affect and emotion hold strong links to perceptions of the effectiveness of risk managers, such as trust and credibility, and in turn to the willingness of stakeholders to engage in a policy-focused dialogue.

Although the mechanisms often remain obscure, it is well known that affective and emotional reactions play a significant role in the processing of information and, as a result, can strongly influence a person's judgments and choices. Currently, the Tampa Bay NEP appears to be widely viewed as a positive and responsible force for change. But if the "low hanging" fruit analogy is correct, then as higher-cost and less-visible actions (i.e., less-accessible fruits) become the focus of attention, retention of this positive image may be threatened. It may therefore be wise for the TBNEP to become more proactive in its risk communication initiatives so as to anticipate some negative responses in the future and to contain these by virtue of an open decision process that is defensible and maintains broad stakeholder acceptability.

3.4 Uncertainty

One of the cornerstones of the NEP is high-quality science. Unfortunately, as the program focus shifts from point to non-point sources of N deposition and from land-based to air-borne emissions, the underlying science becomes more problematic. This has several troubling implications: the range of impact estimates may become greater, scientists may disagree with each other's conclusions (regarding the cost of cleanup as well as the magnitude of nitrogen depositions from a source), and the choice of an appropriate policy response may become less clear. Although careful studies may reduce some of this uncertainty, much will be unresolvable in the short run given the nature of the processes in question and the newness of the science.

A variety of approaches from the decision sciences may be useful at Tampa Bay in terms of working with this uncertainty regarding physical processes or the efficacy of proposed treatments. For example, the decompositional emphasis of multiattribute techniques (Keeney & Raiffa, 1993) is often helpful in breaking highly complex problems into simpler parts, which is useful as tool for stimulating dialogue and introspection among dissenting scientists. Decision trees (Clemen, 1996) are often used as a way to explicitly incorporate, and to compare, probabilistic judgments about the likelihood of a series of events. Adaptive management approaches (Holling, 1979; Walters, 1986), which advocate flexibility in the face of uncertainty and embrace an explicitly experimental approach to learning, also have been widely employed as a means for managing environmental risks and dealing constructively with change.

3.5 Time

The decisions being made at Tampa Bay involve time as a central feature, both in terms of the decision making process itself (i.e., some decisions are made quickly, others require extensive consultation and discussion) and in terms of their impacts (i.e., some decisions result in short-term effects, others in consequences that accrue over decades). In order to facilitate making decisions over different time periods, policy analysts and economists have developed the notion of a quantitative discount rate: the rate by which future outcomes can be expressed in terms of the present. Generally, a project's returns are thought of as a stream of benefits and costs over time, discounted back to Year 1 (so comparisons can be made) using a discount rate of 4% - 10%. This has the practical implication that costs or benefits occurring later count less than those occurring sooner and, by extension, that impacts occurring more than about twenty years from now are essentially negligible in terms of the quantitative analysis of impacts.

Recent work by decision scientists has shown that this practice, although widely accepted, may be too simple. For example, people tend to use higher discount rates for near-term than for far-term events (Loewenstein & Prelec, 1992), which suggests that using a single higher rate may unfairly diminish the value of longer-term outcomes. Studies also show that people tend to use lower rate for losses than for gains (Benzion et al., 1989), which is consistent with the higher value placed on losses. There is also some indication that people may hold different discount rates depending on qualities associated with the items in question, which may in part be why several studies have found different rates for financial and for environmental goods. These results may be important in developing long-range plans at Tampa Bay, because recommended actions will result in impacts over different time periods (e.g., after wastewater treatment plants reduced their N loads in 1980, ambient chlorophyll concentrations in the Bay did not respond for nearly 5 years). In addition, whenever a variety of different economic, environmental, and social effects occur, it is likely that some consequences will take place more quickly than others; for example, economic impacts often occur more quickly than do biological effects. This can lead to asymmetric distributional impacts in the short run and, in turn, to questions about the equity of program actions.

3.6 Defensibility

The criteria by which decisions come to be viewed as legitimate and defensible is at the intersection of the decision sciences and political science, psychology, and negotiations. For the decision maker, establishing and documenting a justifiable *process* for making a decision is often critical, particularly in situations where uncertainty is high and so the *outcome* is difficult to predict. In such cases, a decision science perspective emphasizes that a good decision process cannot guarantee a good decision and, in turn, a good decision cannot guarantee a good outcome (e.g., due to factors external to the decision environment, such as the weather or national politics, that may affect how things turn out). However, a good process can provide a strong rationale for what is done and encourage stakeholder buy-in to recommended actions.

Up to this point, it has been important for the Tampa Bay NEP to demonstrate the use of "state of the-art" science as a means for achieving legitimation. However, as the policy choices become more difficult, the importance of being able to justify program decisions may increasingly mean that managers face a tradeoff with other objectives, such as achieving the lowest-cost solution or achieving the best outcome (because of its greater uncertainty in comparison to other alternatives). In such cases, we expect that a greater reliance will need to be placed on the decision process as a basis for the legitimacy of TBNEP actions, in part because the outcomes of recommendations will become more difficult to predict. We also anticipate that legitimation criteria such as the understandability, accuracy, equity, or transparency of proposed actions will need to be identified more directly by the Tampa Bay staff in the future and, in turn, used as explicit criteria for assessing alternative policies.

4.0 Research design: Decision science techniques to address key issues at Tampa Bay

The focus of this section of the research plan is the use of widely-employed decision science tools to help the Tampa Bay NEP understand and respond to public concerns stemming from environmental policy initiatives at Tampa Bay. The discussion is oriented around four topics that appear to be critical determinants of the long-run success of the Program, based on materials distributed by the Tampa Bay NEP office (in particular, Holly Greening) and the Washington EPA office (in particular, Angela Nugent). Each of these topics represents a challenge and, as such, can be viewed as either a problem or an opportunity. In each case, appropriate decision-science techniques are briefly noted and special implementation concerns are highlighted.

In evaluating the appropriateness of these methods, it is important to keep in mind that, although many techniques of social scientists are different from those of natural scientists, similar criteria exist for distinguishing a high-quality from a low-quality performance on the part of the researcher. Thus, social scientists follow a hypothesis-based model, establish meaningful peer-review processes, and disagree about the interpretation of data just as do their colleagues in the natural sciences. There is art and an interplay of values and methods in the practice of social sciences such as decision making or psychology or economics but (arguably) no more so than in the practice of natural sciences such as biology or ecology or chemistry (von

Winterfeldt & Edwards, 1986). Further, social science investigations of ecological risk follow the familiar pattern of determining what considerations and factors are appropriate (risk perceptions), how the problem can best be assessed or evaluated (risk assessment), what conflicts contextualize and balance the formal analyses (risk management), and how best to communicate results to peers and to a more general audience (risk communication) (Fischhoff, 1989). The discussion of the four topics presented below follows this same pattern, starting with participants' values (perceptions) and scientific uncertainty (assessment) through to tradeoffs and balancing objectives (management) and, finally, to a discussion of communication needs.

4.1 Understanding stakeholders' values and concerns

Issue

What values held by people living in the Tampa Bay area are likely to be affected by TBNEP actions? How are participants' different concerns or values related? For most people, for example, nitrogen deposition is only one component of a much larger package of environmental considerations, including emissions of ozone, public transportation options, and population growth in the area and the state. These concerns, in turn, link to issues of control (to what extent should regulations limit the actions of individuals?), governance (to what extent should outsiders have a say about our city or region?), collaboration (when do community participants work together?), and timing (how urgent is it that activities be undertaken right away?) that can strongly influence the acceptability of different policy options. Disentangling these different influences and sources of value is essential to permit the development of policy options, and (subsequently) their evaluation, in ways that help to ensure that stakeholder assessments are defensible and address those elements of a plan that decision makers think are being evaluated.

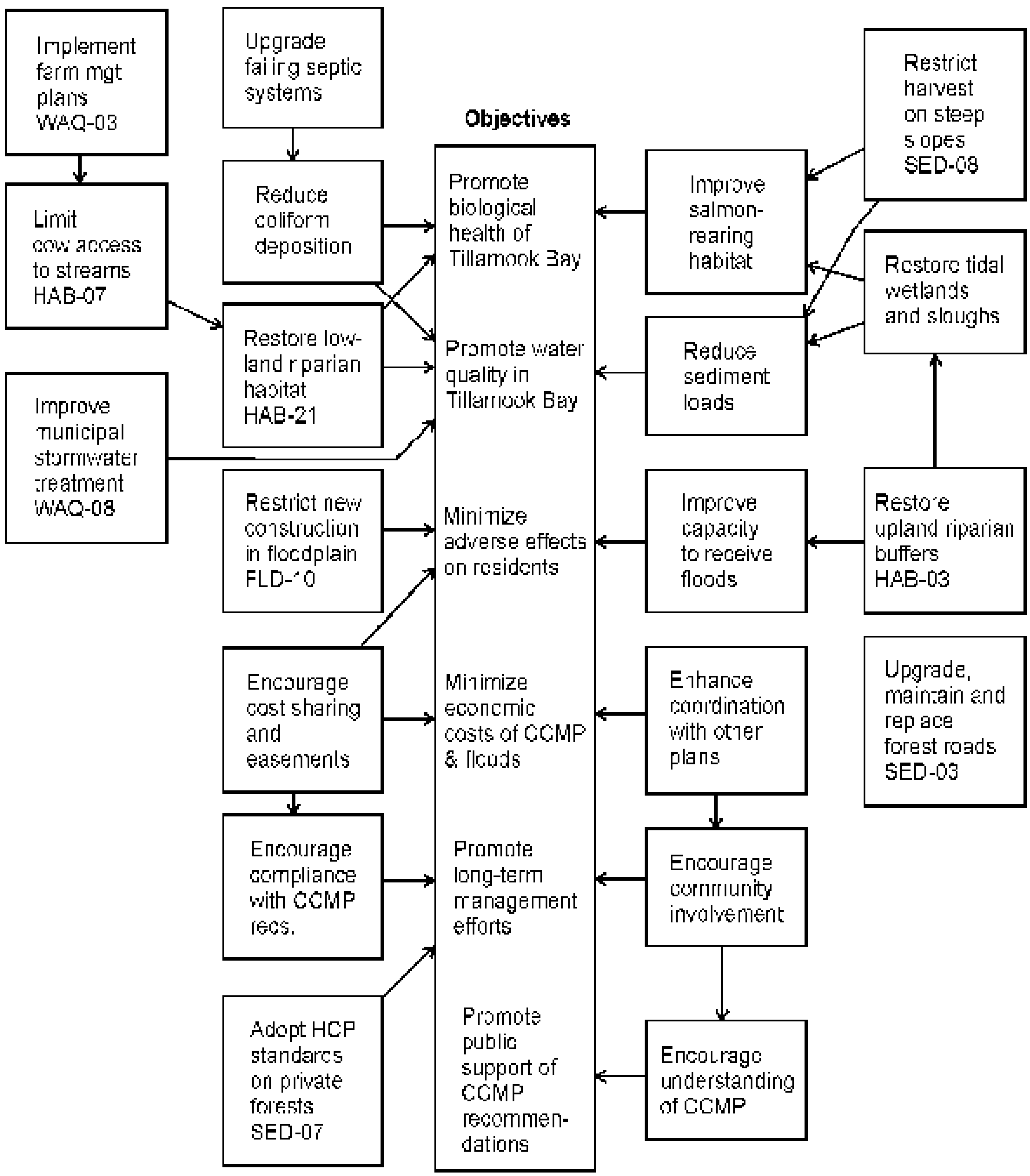
Techniques

A. Small-group structured consultations

For a citizen of the Tampa Bay area, it is difficult to know how to think about the relative benefits, costs, and risks of any proposal to decrease the deposition of airborne nitrogen to the estuary. For one thing, the relevant values change as the specific problem changes. Further, any choice is likely to involve conflict across different types of values: protection of the environmental will increase and so, presumably, will both human and ecological health (which is good), but there will be some economic costs involving, perhaps, the loss of jobs or revenue (which is bad) and perhaps some social or cultural changes (which may go either way). In many cases, the achievement of a primary goal of the Program, such as reducing nitrogen from emission sources, may yield related benefits that are just as important, such as sediment removal and the reduction in toxics from suspended solids associated with the completion of stormwater projects. In addition, some people may feel that the long-term impacts of a policy proposal include changes in the image of the community or in the quality of life for residents (as Tampa Bay continues to grow larger), so that qualitative and emotional considerations might also be important. The problem therefore involves many value dimensions, and each of these different values or objectives (in terms of a specific plan) can be thought about in terms of one or more performance measures or attributes:

Objective	*Attribute*	*Anticipated change*
environment	reduced nitrogen loads	better
health	reduced algae growths	better
economic	lost revenues	worse
social/cultural	new recreation opportunities	???
community image	big city qualities	???
quality of life	stress levels	???

A small group consultation process typically would involve either a cross-section of public and expert views (e.g., 10-15 people who are essentially representative of the diverse perspectives of the area, including public citizen representatives, scientists, industry, and members of the Policy Board) or representatives of a single point of view (in which case multiple groups would be held). In contrast to a more informal focus-group setting, which typically (as in Tampa Bay during the mid-1990s) are called to provide feedback, decision-aiding help is provided by an analyst/facilitator who, working interactively with participants, assists in identifying the key value considerations and in thinking through why each dimension might matter (Keeney, vonWinterfeldt, & Eppel, 1992; Gregory, 2000). This value-structuring goal is accomplished through the use of tools such as *value trees,* which connect higher- and lower-order values, and *means-ends diagrams* (see Figure 2), which separate fundamental objectives (those of essential concern) and means objectives (important because of their indirect effect on more fundamental concerns). Understanding these value distinctions can help in discovering the root causes of disagreements among stakeholders and finding creative policy options.



NOTE: The six fundamental (ends) objectives are shown in the center box. Means objectives, many of which become actions in the Tillamook CCMP, are shown at the sides. An arrow denotes “influences,” between means objectives and from means to ends.

Figure 2. Means-end diagram for Tillamook Bay NEP (from Gregory, 2000).

Means-ends diagrams have proven to be a particularly useful tool in creating alternatives that are responsive to the different values and concerns of stakeholders (Gregory, 2000). For example, one person may view reducing nitrogen loads as a means to reducing algae growth and, in turn, creating higher property values due to improved water quality; for another person, reducing nitrogen loads may be a means to improving fishing opportunities and, in turn, a chance to spend more time on family outings. Both these individuals would care about reducing nitrogen loads but for very different reasons. Similarly, because the benefits of increased seagrass beds may include both improved fisheries and clearer water (as the result of filtering land-based runoff), different policy responses may be favored by residents who view seagrass as a means to either of these objectives as compared to those who primarily value seagrass restoration itself.

B. Structured survey

An alternative to small groups would be to use a structured survey. The type of survey that is envisioned here is very different from the typical opinion poll or attitude survey, which for the most part fail to provide respondents with either the information or context required to form careful and valid responses. As a result, there is often a large gap between the immediate opinions expressed in the survey and people's behaviors and attitudes over the longer run. In structured surveys, in contrast, a series of questions are asked that mimic a conversation, setting up linked sets of questions (or paths; see Figure 3) that probe expressed opinions, allow for learning about one's own values, and test the strength of the different components that contribute to support or opposition toward a proposed management action.

Several different structured survey options are possible. McDaniels (1996) used a structured value survey to conduct a referendum of three alternatives for managing sewage waste disposal in Victoria, Canada. Gregory et al. (1997) used a decision-pathways survey (in which each pathway serves as a distinctive mental model) to compare resident's support for various forest vegetation management options. One advantage, in comparison to small-group approaches, is that more participants can be involved, although somewhat less in-depth responses will be obtained and the time provided for learning is greatly shortened. Another advantage of a survey is that it would permit statistically significant comparisons of the views of different groups living in the Tampa Bay area toward various policy options, including (a) samples split by age, for example residents under age 30 or over 65; (b) a study of the views of newcomers to the area, which could be useful since 300,000 new arrivals are expected by 2010; (c) differences in expressed values by gender or by geographic location, such as people living in different counties.

Implementation

A public opinion poll was conducted for the Tampa Bay NEP in 1991. Since this time, there have been substantial changes in the population of Tampa Bay, in the accomplishments and regional profile of the TBNEP, and in the status of water protection in the estuary. For all these reasons -- along with the importance of conducting a more meaningful, value-structured survey -- it is recommended that either small-group consultations or a structured survey be undertaken in the near future. If small-group work is done, both the definition of the problem under consideration and the selection of participants (as representatives) would be critical. If a structured survey is done, it should be designed and the results analyzed by a team with both decision-science and survey research backgrounds, although the implementation of the survey

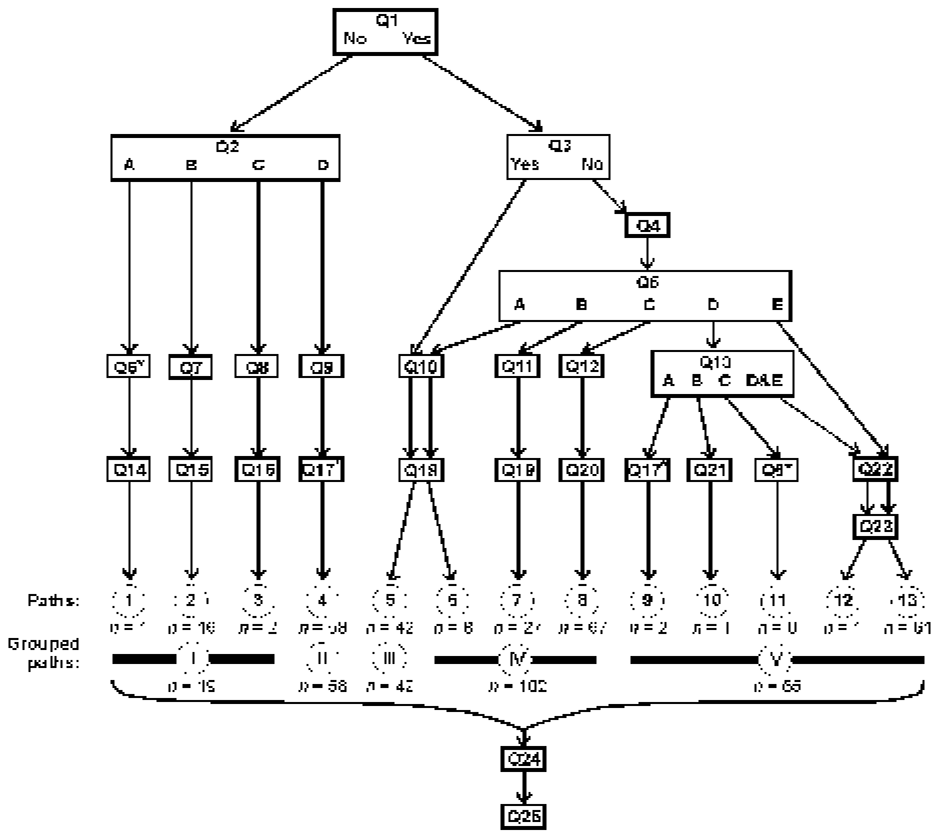


Figure 3. Example branching decision-pathways survey structure (from Gregory et al., 1997).

could be done by any reputable local firm with CATI (computer assisted telephone interviews) capability. Some small-group work should be done in advance, to learn more about value structures of Tampa Bay residents as an aid to survey design and as a guide to the construction of the mental models or pathways.

Costs for the small-group structured consultations would vary with the length of time that the group, or groups, were to meet. Much can be learned through one (or several) “decision framing” workshops lasting two-three days and focusing on the framing of the problem and the identification of key decision elements (using basic decision-structuring tools such as vaelu trees, influence diagrams, decision trees, and the like). With up-front preparation and a final report, each workshop might cost $20 -25,000. Ongoing groups, meeting perhaps once every two weeks for a period of several months, would involve higher expenditures (e.g., $50,000 - $75,000) but typically are required in situations such as protection of the Tampa Bay estuary where multiple value dimensions are involved and the management actions are relatively complex . A structured survey would cost perhaps $135 - $150,000, including a subcontract of approximately $50 - $65,000 for the conduct of the survey itself (which presumably would go to a local firm with computer-assisted telephone interview capabilities). The remaining $85,000 would roughly be split equally between initial small-groups, survey design and pre-testing, and data analysis and reporting.

4.2 Understanding scientific uncertainty

Issue

Scientists do not know all they want to know about the deposition of nitrogen into the Tampa Bay estuary. The importance of these knowledge gaps is expected to increase as the focus of the TBNEP moves from land-based to airborne depositions. This uncertainty has several implications:

- creates large ranges associated with the quantity or timing of anticipated impacts, typically due to the uncertainty associated with discrete future actions or with a lack of study results. For example, if Tampa Electric Company switches a large power plant from burning coal to natural gas, nitrogen deposition to the bay could be reduced by several hundred tons each year.

- creates controversy among scientists, due to disagreements in their interpretation of data. For example, estimates for airborne nitrogen deposition in 2010 range from 150 tons/year to 580 tons/year (Greening, pers comm), which is a large range and creates problems for policy formation as well as stakeholder communication efforts. Presumably, some scientists will think the lower end of this deposition range is more likely, others the high end; knowing more about their reasoning could help to narrow the range and improve management.

- creates frustration among residents, who typically believe that good science is not equated with uncertainty. Over time, a failure to understand the reasons for the uncertainty in consequence estimates can lead to an erosion of support for the TBNEP (as well as, from a technical perspective, inferior policy choices).

Techniques

A. Decision trees and event trees

Decision trees, event trees, and influence diagrams (which help to show the structure of problems; see Section 4.4) are all commonly used to help individuals think through a range of different decision possibilities. They provide useful visual and computational assistance in the many cases where a combination of decisions, consequences, and probabilities quickly results in problems of daunting complexity (Keeney (1982: 806) defines decision analysis as "a formalization of common sense for decision problems which are too complex for informal use of common sense."). Both decision and event trees flow from left to right, with branches representing the different alternatives that are possible. The primary elements include:

- decisions to be made (represented by squares)
- chance events (represented by circles)
- consequences (specified at the ends of branches).

An example decision tree (simplified, but with all three elements included) is shown below.

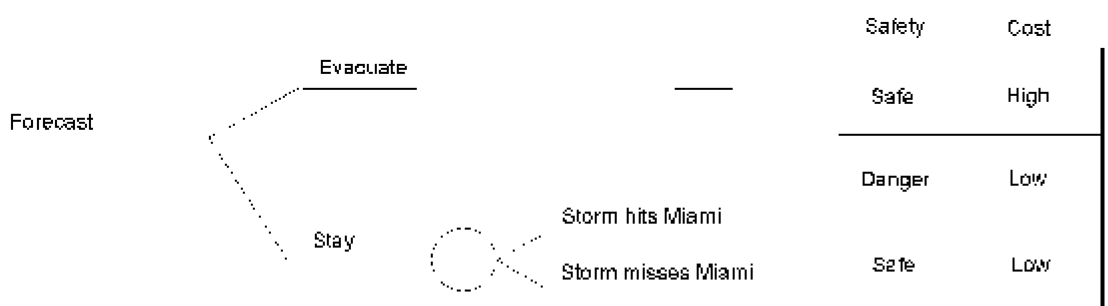


Figure 4. Example showing key elements of decision tree (from Clemen, 1996)

Formal rules exist for the development of a detailed decision tree; for example, the branches from each chance node must correspond to a set of outcomes that are mutually exclusive (i.e., only one of them can happen) and collectively exhaustive (i.e., one of the specified outcomes has to occur). The order in which elements are shown is also crucial; placing a chance event before a decision -- the probabilistic future price of natural gas before a decision to convert -means that the decision is conditional on a specific chance event having occurred (e.g., if gas price is high then don't convert, if gas price is low then convert). Key elements to be included as part of an influence diagram or a decision or event tree for Tampa Bay might include:

- whether Tampa Electric Co. power plant switches from coal to natural gas
  - no switch (due to price increases for natural gas)
  - small plant switches from coal to gas (sooner vs. later)
  - large plant switches from coal to gas (sooner vs. later)

- whether a new natural gas pipeline is completed to Port Manatee
  - new merchant plants are built to provide power to grid
  - no new merchant plants are built
- the magnitude of future population increases in Tampa Bay
  - 10% growth, 2000 - 2010
  - 20% growth, 2000 - 2010

Decision trees are also a useful mechanism for displaying the sequential nature of some decisions: one action must be taken first in order to facilitate a later, related action. Questions of timing, and in particular differences in the timing of the economic and biological effects of NEP actions, are likely to become increasingly important over the next 10-20 years.

B. Expert judgment elicitations

If a decision tree were to be used to clarify the importance and probability of future outcomes at Tampa Bay, where would the information for each branch of the tree come from? In some cases existing local data bases will be adequate and, at times, information from similar locations will be helpful (e.g., areas where power plants underwent similar types of fuel conversions). In many cases, however, the best information will reside in the minds of experts. In such situations, a decision-science perspective advocates the use of a structured, quantitative process for eliciting this information (Keeney & von Winterfeldt, 1991). One reason why a quantitative process is recommended is that qualitative statements of uncertainty (e.g., "a small chance") are vague and can have different meanings to different individuals. Qualitative statements also can mask vagueness about the question being judged and hide important variations among the selected experts. In addition, it helps to assess the confidence that each expert has in his or her own judgment and to establish a consistent basis for collecting the knowledge so as to facilitate the comparison (and aggregation) of judgments across individuals.

In the typical case, information is collected in the form of a cumulative probability distribution, showing (for the event in question) the 0 - 1 probability associated with the occurrence of different levels of the event. Responses are shown as probability distributions, which both quantifies the expressions of likelihood (e.g., the implied probabilities when an event is said to be "highly likely" or "nearly impossible" or "occurring reasonably often"?) and facilitates the visual comparison of the judgments. Some training in decision making is often helpful, so that the influence of some of the more common biases in judgment can be minimized.

For most problems, posing questions as part of an expert judgment elicitation helps to highlight unanticipated differences in interpretation. For example, suppose the question (see Figure 5) is

“How much additional seagrass do you think will grow back into this specified area (as shown on a map) by 2010." Different people may interpret the question differently -- What is the starting point for the “additional” growth? Are all types of seagrass covered or only certain types? How established does the seagrass need to be to count as having grown back? --but even after these issues are made explicit, the range of estimates derived from the experts may well differ significantly. This is illustrated in the three example distributions shown below, which vary in terms of how much seagrass currently exists (compare experts A and B), the time-path for future growth (compare A and C), how the problem is decomposed (see expert B), and the eventual maximum amount (compare B and C).

Despite these differences, in a typical case the individuals would be unaware prior to the elicitations that such large differences existed among their perspectives, because the questions never had been posed in quite this way. In all such cases, a related recommendation is that the variations should not be suppressed but rather explored carefully, to encourage an open exchange of information which might then lead to additional consensus among the group or, perhaps, to the identification of further studies.

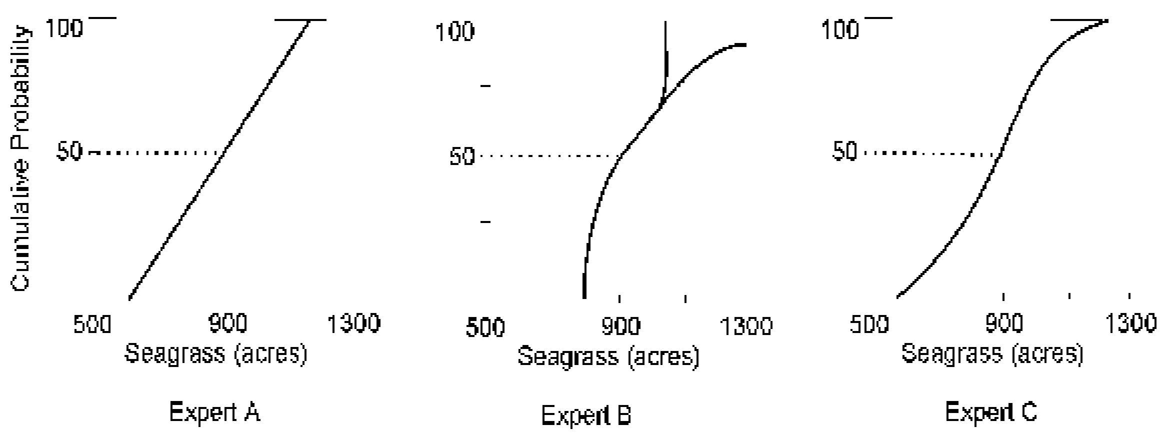


Figure 5. Example cumulative probability distributions from three experts for the question. How much additional seagrass will grow back into the specified area by 2010?

C. Adaptive management and learning

Different management responses can be made in response to uncertainty. One is to essentially ignore the uncertainty by going with the most likely scenario. Another is to postpone any decision until more information becomes available and the uncertainty is reduced or resolved. A third possibility is to undertake multiple approaches and retain flexibility as results are monitored and more is learned. An adaptive management approach embraces this third path, incorporating an active approach to learning as part of protection activities. Based on ideas of the ecologists C.S. Holling (1979) and C. Walters (1986), adaptive management incorporates an explicitly experimental approach to learning as a way to reduce uncertainty. By carefully monitoring results (e.g., the ecological, social, economic, and cultural impacts of alternatives) and incorporating mechanisms for learning from successive trials (which may occur at one location or at many locations), an adaptive approach (see Figure 6) recognizes that some failures will need to occur in order to learn about the limits of a system and to retain flexibility in management options.

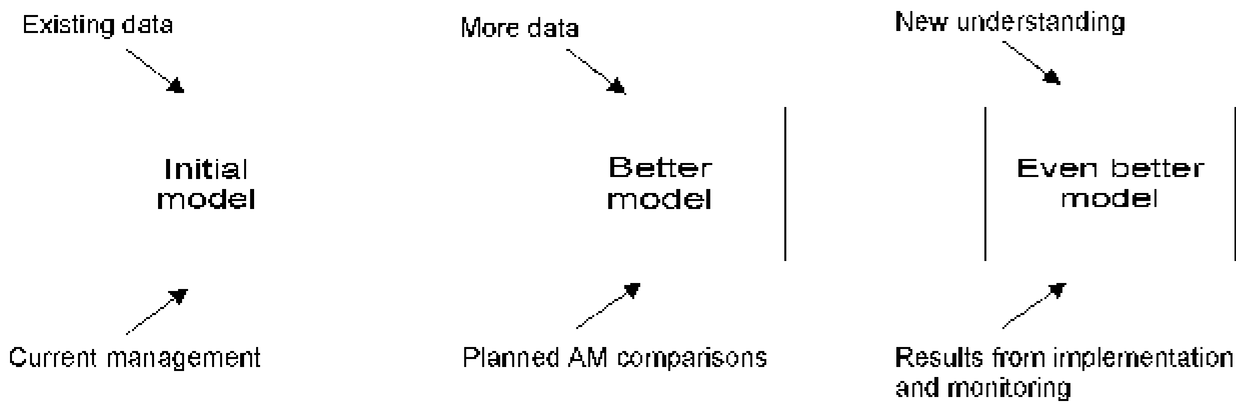


Figure 6. A model of the adaptive management process (based on Holling, 1979)

Nevertheless, the barriers to adaptive approaches that provide learning are formidable, arising from the political, institutional, and human settings in which risk management efforts are pursued (Gunderson, Holling & Light, 1995). As a result, most of the major planning exercises for implementing adaptive management policies have not been carried out, primarily because decision makers wanted near-term solutions or were more concerned with fine-tuning solutions that appeared to be best rather than preparing for the inevitable ecological, economic, or social surprise. Decision-analysis techniques can help to implement adaptive management approaches in three ways: first, by keeping track of the low-probability but high consequence adverse events that can occur if all does not work out as planned; second, by assisting in the development of explicit measures of learning, so that reductions in uncertainty over time are correctly perceived to be a benefit of acceptable risk management policies; third, by helping to set priorities for which management policies are most important to test.

<u>Implementation</u>

An initial focus for addressing uncertainty at Tampa Bay might explore estimates regarding the relative contributions of (a) atmospheric deposition sources of nitrogen from the watershed and (b) airborne nitrogen sources located outside the watershed along with (c) the ecological consequences of nitrogen deposition. These elicitations would seek to identify both the uncertainty associated with future contributions from each source and the uncertainty about the associated effects. Although additional study might be warranted, experience suggests that a great deal could be learned from two short (2-4 day) workshops involving 4-6 recognized experts, who would be given some initial training in the type of judgments required: the first would focus on problem decomposition and structuring the uncertainties, and the second would elicit the probabilities and discuss reasons for similarities and differences across participants. The answers would be important to the overall effectiveness of the TBNEP efforts, because presumably some sources of deposition are more easily controlled than are others and, in addition, mitigation plans should be reviewed and adjusted periodically to reflect the most recent information on protection efforts. Further, if additional studies confirm that atmospheric deposition accounts for as much as 75% of all loadings in the Bay, then there might be regulatory implications in the event that the TMDL (as a measure of the Bay's "assimilation capacity") or other baseline measures of program effectiveness would require adjustment.

Costs for the recommended approaches again would vary depending on the breadth and depth of the analysis. Significant insight into the structure of ecological risk problems and management options can be gained from simple decision trees, in the course of short (3-5 day) workshops that might cost $30,000; clarifying the associated uncertainties and, in particular, conducting studies to test and refine the available information would involve additional resources. Expert judgment approaches naturally lend themselves to short workshops of 2-3 days, but only after a problem has been well defined (although the up-front costs here largely could be borne by the TBNEP staff, with outside decision-science consultants coming in only to conduct the workshop). Typically, consultants might address a series of problems by holding multiple, topic-specific workshops. Adaptive management approaches typically require extensive modeling of options and, often, some initial testing of approaches and monitoring of results. Costs are difficult to estimate, in the absence of a specific proposal, but it is probably unrealistic to think of initiating an active learning process using adaptive management approaches for a commitment of less than $50-75,000 and a time frame involving anywhere from several months to several years.

4.3 Achieving a balanced plan: addressing tradeoffs

Issue

The residents of Tampa Bay want more of many things: cleaner water in the Bay, good employment opportunities, a healthy industrial base, better opportunities for recreational activities, improved health, and reasonable living expenses. Up to this point in time, by and large, they have been able to achieve many of these goals at a low or negligible cost. Over the next decades, however, the inevitable conflict in these multiple desires will become more evident: improvements in one dimension will lead to tough choices and, at that point, help will be needed in constructing a plan that balances the needs of the different public, industry, and agency stakeholders. Whereas economic approaches might seek to estimate the monetary value of proposed plans (in terms of residents' expressed or revealed willingness-to-pay), a decision science approach focuses instead on the balancing of different values and priorities, which involves the explicit consideration and determination of acceptable tradeoffs.

One way in which tradeoffs will show up at Tampa Bay is in the priorities attached by different stakeholders to specific aspects of the estuary protection plan. Understanding the reasons for similarities and differences in the importance of proposed estuary-protection actions will help the TBNEP staff to develop alternatives that are more likely to receive broad stakeholder support. For example, some initiatives attractive to technical experts may receive a surprisingly low level of public support, whereas other initiatives (e.g., seagrass restoration) may achieve a surprisingly high level of support; in both cases, a decision science perspective on problem framing and the construction of value tradeoffs may help to explain these findings. Other important tradeoffs may derive from distributional considerations: tough controls on agricultural runoff or on immigrants presumably would more strongly affect Hillsborough County or Manatee County (which still have large agricultural and range areas) than Pinellas County (which is large built out). Overall, four decision science approaches to dealing with tradeoffs are particularly relevant to the policy choices likely to be facing the Tampa Bay NEP managers.

Techniques

A. Consequence tables

The development of a consequence table is an important step in operationalizing a decision-sciences approach. The idea is simple: for each major action or initiative that is proposed, an "objectives by alternatives" matrix is created that clarifies the consequences associated with each action in terms of the expressed objectives. The various alternatives are shown across the top of the matrix, with objectives shown along the left-hand side; entries display the change in performance measures or attributes of each objective that are anticipated for the designated alternatives. This allows the main impacts of each option to be displayed in a way that quickly identifies how participants' values will be affected and whether all important considerations are being evaluated. The use of a consequence matrix also eases the visual identification of dominated alternatives, in which one option is clearly better than another on all criteria.

	Alternative A	Alternative B	Alternative C
Objective 1			
Objective 2			
Objective 3			
Objective 4			

Example Consequence Table

The consequence table provides a surprisingly powerful tool for the analysis of competing options. If it is comprehensive, then all reasonable options are shown (in terms of the listed alternatives) as are all reasons why any alternative will matter (in terms of the objectives). Anything left off the table is unimportant -- either its consequences are not important (in which case no associated values are shown) or its consideration is not realistic (in which case it does not represent a viable alternative). Different options may be weighted differently by different stakeholders, in terms of the relative importance of objectives (including zero weights on some objectives). Further, the consequence table can assist in creating new alternatives (for the example, new options “D” or “E”) that combine some of the good ideas already generated in novel ways and may be preferable to any of alternatives previously discussed.

B. <u>Swing weights and even swaps</u>

There are many different methods for helping stakeholders to think through tradeoffs and their implications. One widely-adopted approach, known as “swing weighting,” starts with the description of a hypothetical alternative that would result in the worst level of impact for each of the expressed values (e.g., the fewest acres of habitat restored, the lowest number of jobs, etc). Participants are then asked to rank the objectives in terms of which impact they would most prefer to “swing” from the worst to the best (e.g., the most acres of restored habitat, etc.). In a subsequent step, the ranked objectives are rated quantitatively so that explicit comparisons of their relative importance can be made (keeping in mind that these ratings are specific to the problem context under consideration). The more important dimensions of value then will be weighted more heavily in the subsequent decisions. Similar results can be obtained using paired comparison and a variety of other weighting approaches; the choice of a technique should reflect the cognitive styles and capabilities of the group or individuals involved (von Winterfeldt and Edwards, 1986).

Another tradeoffs technique builds on the use of a consequence table to simplify decisions by focusing on the elimination of dominated alternatives (or alternatives that are so close they can be considered to be “practically” dominated; see Hammond, Keeney & Raiffa, 1999). By looking for “even swaps”, the two options are rendered equivalent for the cited dimension of value. An example would be a choice of jobs in two cities: the choices might differ in terms of responsibilities, salary, and (for the cities) rainfall, but if the cost-of-living-adjusted salaries offered are the same (or nearly the same) then this dimension is not helpful to making the choice because it does not discriminate between the jobs.

Consider, in the case of Tampa Bay, the three alternatives shown below. Each represents a simplified plan for restoring a portion of the estuary. Only three consequences are shown: the cost (in millions of dollars), the new fish rearing habitat that will be created (in acres), and the new days of recreational fishing. At first, the choice between A, B, and C appears confusing: C is cheaper but also has lower environmental benefits and creates fewer recreational options,

	Alternative A	Alternative B	Alternative C
Cost ($)	40	55	30
New Habitat (Acres)	115	210	100
Rec’l fishing (Days)	18	15	9

whereas B provides the most new fish habitat but also costs more whereas A is best for recreation. Looking only at Alternatives A and B, suppose that people are willing to pay $15 million (but no more) to create 60 additional acres of habitat. Reflecting this “even swap” tradeoff in A (as shown below), the cost rises to $55 while the new rearing habitat increases to 175 acres. For the two objectives cost and habitat, the choice between A and B is now easy: B is clearly superior, because the costs are equal (so this dimension becomes irrelevant to the choice) and B provides an additional 35 acres of habitat. By working through even swaps for the other tradeoffs, in turn, the choice of a preferred alternative will gradually become clear.

	Alternative A	Alternative B
Cost ($)	~~40~~ . . . 55	55
New habitat (Acres)	~~115~~ . . . 175	210

C. Reference points: Understanding gains & losses

A decision science perspective on gains and losses helps to understand the question: Why is the support for some components of protection plans surprisingly strong and, for others, weaker than anticipated? The answer comes back to the Section 3 discussion of framing and the finding that some changes are coded as gains whereas others are coded as the restoration of losses. Given the asymmetrical value function of Prospect Theory (Kahneman & Tversky, 1979), losses count for more than gains. Extensive research in the decision sciences has demonstrated that the framing of options as the restoration of a loss or damage rather than as a gain or improvement can result in a 2- or 3-fold difference in expressed measures of value (including dollar-based valuations such as expressed willingness to pay).

The technique for distinguishing gains from losses is simply to ask people how they think about a proposed action. Their explanation -- in terms of whether they naturally adopt a gain or loss as their reference point -- will help to explain differences in public responses to proposed actions, for example why there is such broad support in the Tampa Bay area for restoring sea grasses to 1950s levels. If the reference point were current conditions (see Figure 7 below), then each new acre of seagrass would be viewed as an improvement or gain. But if the reference point were the 1950s, then each new acre would be seen as reducing an experienced loss and, therefore, worth more. Generally, the restoration of a prior loss will be considered more valuable -- by a factor of two, three, or more -- than the achievement of a similar gain (Knetsch, 1990; Gregory, Lichtenstein & MacGregor, 1993).

The framing of changes as gains or losses also carries emotion and affect. The value structuring techniques described earlier help to capture this more qualitative side of stakeholder responses and enlarge the domain of concerns that are considered legitimate. This adds credibility to the consultation and evaluation process and helps to increase its ability to absorb, and be responsive to, changes in stakeholder perceptions over time.

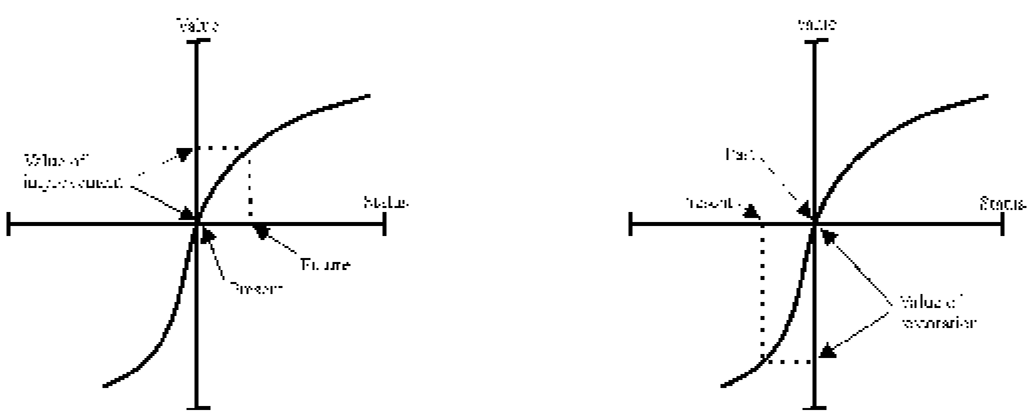


Figure 7. Comparison of environmental gains and losses (from Gregory, Lichtenstein & MacGregor, 1993).

D. Evaluability

Participants in public consultation processes are often asked to provide input in ways that are not at all user friendly from a decision making perspective. For example, participants in an economics-based evaluation study (e.g., a typical Contingent Valuation survey) might be asked whether they would willingly pay an extra $20/year in added local taxes in support of an action that would yield higher levels of water quality. The problem with such questions is that the decision context is not easily evaluable, because there is nothing to compare it to: How else could the $20 be spent? Are there other plans for protecting water quality? How much would they cost? Would almost the same benefits be realized for $5/year? Could much more be accomplished for $25/year?

Techniques for incorporating concerns about evaluability address questions such as these by recognizing that comparative judgments across dimensions are easier than single judgments that lack a frame of reference. Consider the following example from a study by C. Hsee (1996), one of the originators of the evaluability concept. A choice is to be made between two dictionaries. One dictionary (A) has 10,000 entries and the cover is like new. The second (B) has 20,000 entries but a torn cover. Which would you prefer? Three identical groups of subjects were selected. A first group was given Dictionary A, a second Dictionary B. Participants were willing to pay more for Dictionary A ($27) than for Dictionary B ($20), suggesting that the torn cover (an affective dimension) counted for a lot:. A third group of subjects was given information on both dictionaries and asked to assign prices. For these participants conducting a joint evaluation, the preference was reversed and Dictionary B was now priced higher ($24 as compared to $19). Which is the better evaluation process? A decision science perspective would argue strongly for the joint evaluation with explicit information presented on the multiple dimensions of the choice. The reason is that, in joint evaluation with multiple alternatives, participants were able to compare one option to another and, as a result, the more difficult to evaluate attributes (in this case, the number of entries) became easier to consider and, therefore, exerted a relatively greater influence.

The concept of evaluability has important implications for the presentation of information to the Policy Board and other citizens of Tampa Bay. Including multiple alternatives and presenting information about how they compare on specific outcome or process attributes will help to ensure that the implications of all relevant alternatives are understood and that, by comparing dimensions of value, the more difficult-to-evaluate aspects of alternatives will not be neglected. As a result, a higher quality choice will be made -- one that is more likely, in the long run, to reflect the interests of decision makers and to improve the welfare of citizens of Tampa Bay.

Implementation

Each of the approaches introduced for dealing with tradeoffs -- consequence tables, even swaps, reference points for gains or losses, and multiple alternatives for improving evaluability – seek to provide information that makes it easier for individuals to consider tradeoffs in their judgments about an action. Any of these approaches is compatible with either small-group or survey formats. Including information of this type helps individuals to think about tradeoffs, which often are cognitively and/or emotionally difficult (and, at times, are therefore resisted), and it helps to broaden the communication process because trade-off judgments are elicited directly from stakeholders. If policy makers fail to elicit explicit tradeoff judgments then the consultation process is open to criticism: participants are not fully informed, and the interpretation of information about their preferences by the decision makers may not mesh with what people truly desire.

Costs for implementing these techniques are relatively low, particularly in light of the insight that can be achieved. Both consequence tables and even swaps involve a different way of organizing and looking at information that already may be in hand, so it is again a situation where substantial gains can be made -- including, in many cases, the creation of new alternatives -- in the context of a 2-3 day workshop (so, with some time for preparation and reporting, perhaps $25-30,000). Bringing in techniques for recognizing and working with both gains/losses and evaluability issues need not involve any additional costs; it is more a question of adopting a behaviorally-informed perspective that is more in line with how people naturally think about and address a wide variety of policy and management problems.

4.4 Communicating with stakeholders

Issue

Two aspects of communication are important to the Tampa Bay estuary protection efforts. The first, which seems to have been done very well, involves helping the public to know about the initiatives under consideration as part of the TBNEP and how they can contribute to the TBNEP program (including specific information about whom to phone or e-mail, how long to expect to wait for a reply, the status of current initiatives, etc.). The second type of communication is about building an understanding of stakeholders' concerns and developing broadly-acceptable actions that will help to protect the estuary. This second type of communication involves the establishment of trust and an ongoing two-way dialogue, about factual information as well as values and emotions and ethical principles, and fits within the broader framework of achieving negotiated settlements or creating alternatives that are supported by key participants. Topics include (a) how complex scientific issues, such as the mechanisms by which nitrogen is deposited from the air, can be presented so that the choices made by public stakeholders are well informed from a technical perspective and (b) how complex values and tradeoffs, including the observed willingness of citizens to support restoration activities more strongly than they will support environmental improvements, can be presented so that both technical stakeholders and policy makers are well informed about the views and opinions of citizens.

Techniques

A. Influence diagrams

Earlier sections discussed the use of decision-science techniques for distinguishing means from fundamental objectives and for developing value hierarchies. Influence diagrams are a closely related technique for structuring the various elements of more complex decisions -- what choices are to be made, what alternatives are available, what uncertainties are important, and what are the likely outcomes. In the context of communicating with stakeholders, influence diagrams constitute a simple and effective tool for clarifying what needs to be communicated about and, thus, provide an accessible technique useful to all parties in making sure that communication efforts are sufficiently comprehensive and detailed (Shachter, 1986).

The essence of an influence diagram (as with a decision tree) is the use of different shapes for different decision elements (or nodes), which are then linked with arrows to show their relationship (see Figure 8). Decisions are represented by rectangles with square corners and chance events by ovals. A rectangle with rounded corners represents consequences (as well as some other related uses). In the simple influence diagram shown below, the decision by partners of the TBNEP is whether investment funds should be committed to a specified estuary protection action. There is uncertainty about whether the investment will fail or success, which in turn affects the return on the investment (i.e., the consequence). The investment node influences the return, but there are no arrows from the chance node to the decision because at the time the decision is made it is not known whether the action will succeed. This same logic is helpful in more complex decisions in tracing through an anticipated sequence of events; probabilities for different levels of success also can be entered if this information is available. The use of even very simple influence diagrams can help to demonstrate how stakeholders understand a problem and, in turn, whether the information that is provided to them is sufficiently complete for an informed decision to be made.

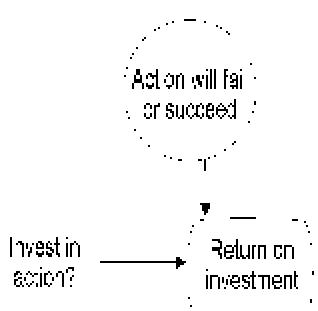


Figure 8. Example influence diagram for an investment decision by TBNEP partners

B. Mental models

A key aspect of communicating effectively with different stakeholder groups is learning about the mental models they employ to make sense of information and to help evaluate choices or policy options. As developed in the past decade (see Bostrom, Fischhoff & Morgan, 1992), a mental models approach uses the results of loosely-structured interviews to map out how an alternative is thought about, based on a picture of the key relationships among cognitive components. Different models are likely to exist for different groups, so an important consideration is the number of groups that will be considered and the depth of responses that will be used to characterize their thinking. This information, in turn, is very useful to decision makers who are seeking to communicate with these individuals because it helps to identify the types of cause-and-effect linkages believed to exist.

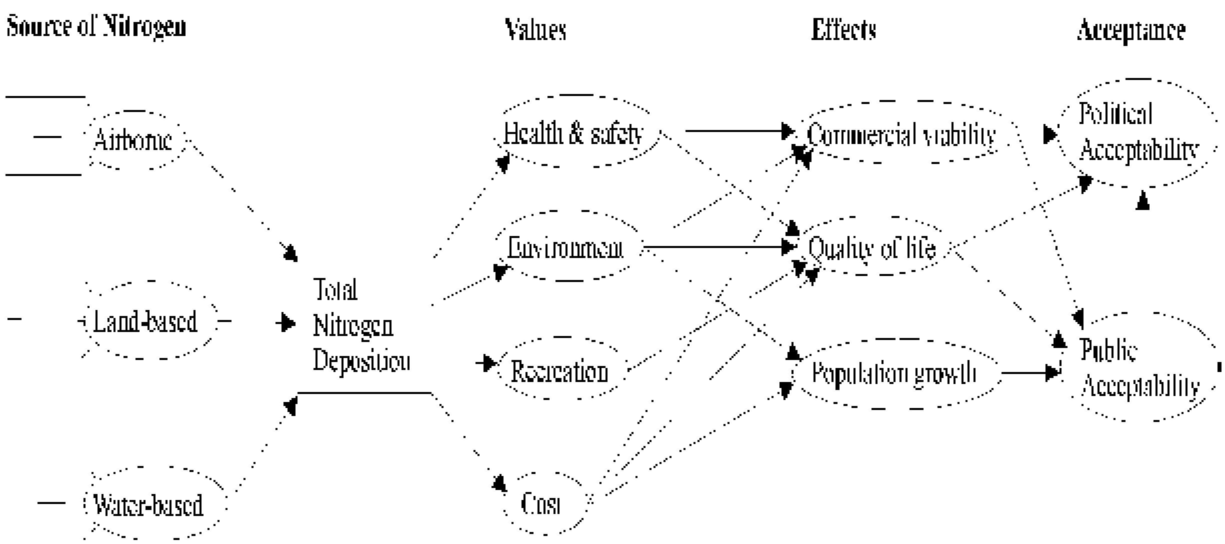


Figure 9. An illustrative mental model for Tampa Bay

At Tampa Bay, a natural use of mental models would be to help understand the processes thought to be involved in the air deposition of nitrogen. What sources of nitrogen are considered to be most important? What do people think happens to the nitrogen once it is in the water? What types of experiences are thought to be affected by higher or lower rates of nitrogen in the air and in the water? This information is helpful as a way to understand the concerns of Tampa Bay residents and as a way to anticipate their responses to proposed plans.

<u>Implementation</u>

Both influence diagrams and mental models represent techniques that are designed to foster understanding through a two-way dialogue between the TBNEP and its various stakeholders (as well as among the stakeholders themselves). They are common sense applications of decision science concepts, proven to be helpful in organizing communication and in facilitating meaningful exchanges. In contrast to some of the other decision science tools (e.g., for dealing with uncertainty), the basic use of both influence diagrams and mental models can be taught quickly and these techniques can be employed readily in helping to understand stakeholder values and to develop directly responsive ecological risk policies.

Costs associated with influence diagrams, as with other problem-structuring techniques used by decision scientists, are relatively low and often significant progress can be made in understanding stakeholder values related to an environmental risk problem in the course of a 2-3 day workshop (as previously noted, costing perhaps $25-30,000 including some preparation and reporting costs). Although the workshop might have a specific issue focus, the benefits of using these techniques would extend to other problems facing the TBNEP. Mental models research typically requires a more extensive involvement with stakeholders and some interaction over several weeks or months to conduct personal interviews and to adjust and refine insights, so that costs of perhaps $50 - 75,000 would be typical.

5.0 Summary schedule and costs

Developing a schedule and proposed costs for Implementation of these suggested approaches at Tampa Bay is difficult for two reasons. The first is that limited information has been provided regarding the current status of knowledge about the values and tradeoffs of different stakeholder groups. The second reason is that several of the proposed techniques can be used either as stand-alone approaches for understanding the values and reasoning of public and expert stakeholders or, alternatively, they can be used in association with one or more other techniques. For example, small -group structured consultations can provide substantial insights on their own or, in some cases, they can provide input to a structured survey. In both cases, the scale and costs of the effort will, in turn, vary greatly with the scope of the data that is desired and the types of information concerning subgroups within the population (e.g., splits of the sample by geographic location, length of residence in Tampa Bay, age, gender, or preferred activities). All these questions can of course be addressed through discussions between potential decision science consultants and the TBNEP staff, but these discussions have not yet taken place.

There are also close linkages among the different techniques that are presented in Section 4. For example, influence diagrams are often used as part of value-structuring efforts along with value trees and decision trees. All three of these tools are frequently used together as part of expert judgment elicitations, and influence diagrams are employed as aids to help build common understanding among technical experts (similar to the use of hypothesis diagrams). Mental models of experts also can be used as a tool to help understand the reasons for differences of opinion among scientists. Using even swaps to simplify a decision requires the prior construction of consequence tables, which in turn serve as an aid to the comparison and evaluation of options. There is also extensive feedback from the facts-based to the values-based portions of the overall approach. For example, an adaptive management trial may provide information that influences what is known about the range of likely effects of a proposed action and this, in turn, may influence the priority assigned by stakeholders to certain of their value judgments. Thus, the linear presentation followed in Section 4 masks the close interrelationships among the use and results of many of these techniques in practice.

Approximate study schedule

September 2001....................................*June 2002*..*March 2003*

Discussions with TBNEP staff...

Understanding stakeholder values and concerns..

Small-group structured consultations..

Structured survey (options)...

Understanding scientific uncertainty..

Decision & event trees...

Expert judgment elicitations..

Adaptive management and learning ....

Achieving a balanced plan: addressing tradeoffs

Consequence tables, swing weights, even swaps.............

Reference points (gains & losses)...................................

Presentation of options (evaluability)............................

Communicating with stakeholders...

Influence diagrams...

Mental models..

The proposed schedule shows a start date for the anticipated studies of September, 2001 and a completion date approximately 18 months later. Following initial discussions with the TBNEP staff and with key local, state, and federal Partners, a likely starting point is to begin with dual efforts aimed at improving (a) the understanding of similarities and differences in stakeholder values and concerns and (b) the understanding of scientific uncertainty associated with airborne depositions of nitrogen to Tampa Bay estuary over the next 20-25 years. These studies would take place over approximately a 6-9 month period. Incorporating this information as part of specific plans and proposals for actions would then take center stage, with issues of tradeoffs being addressed by community and value-based participants and issues of reducing scientific uncertainty and learning being addressed by technical and science-based participants. The time-frame for these components of the overall decision-science studies is again difficult to estimate but is depicted as occurring primarily over a 9 month period.

Communication with the full range of stakeholders is shown as taking place throughout the study. This communication would continue to occur after completion of the specific decision-science research by the consultants, with members of the TBNEP staff taking the lead and using new decision-science tools to help ensure that meaningful, two-way communication occurs on a regular basis.

The estimated costs of each activity already have been noted as part of the Implementation portions of the Section 4 review. These costs are summarized below.

Estimated study costs (personnel only)

Discussions with TBNEP staff		$ 20,000
Understanding stakeholder values and concerns	$ 30,000 -	$135,000
Small-group structured consultations		
Structured survey (includes subcontract)		
Understanding scientific uncertainty	$ 40,000 -	$ 75,000
Decision & event trees, influence diagrams		
Expert judgment elicitations		
Adaptive management and learning		
Achieving a balanced plan: addressing tradeoffs	$ 30,000 -	$ 60,000
Consequence tables, swing weights, even swaps		
Reference points (gains & losses)		
Presentation of options (evaluability)		
Communicating with stakeholders	$ 25,000 -	$ 75,000
Influence diagrams		
Mental models		

The research plan also is supposed to distinguish between the major components of estimated study costs, including personnel costs, travel, supplies over $1000 (which are not needed in this case) and “other” expenses. The personnel costs that are shown above would vary substantially depending on the stated needs of the Tampa Bay NEP staff, the needs of local Partners (who might, for example, request either frequent or infrequent presentations and updates from the consultants), the ability of the Tampa Bay staff to cover many of the project requirements, and the use of graduate students or other less-senior personnel. For example, the first component of costs (Discussions with NEP staff) was quite low for the work that R. Gregory, K. Wellman, and others completed as part of estuary protection efforts at Willapa Bay, Washington (approximately $10,000) but significantly higher for the work conducted at

Tillamook Bay (approximately $40,000) as a result of the greater complexity of the problems at the Tillamook Bay estuary and the less-complete status of the required natural- and social-science information.

The only significant component of "other expenses" would be the costs of a subcontract to conduct a structured survey of residents in the Tampa Bay region. This is estimated to range from $50,000 - $65,000, depending largely on requirements of the sample size and survey design. No supplies costing over $1000 are anticipated to be required

The proposed decision science contributions to understanding public values and scientific reasoning all involve a significant amount of hands-on work which will need to be done in the Tampa Bay area, often with members of the TBNEP. Depending on the initiatives favored by Tampa Bay staff, it is estimated that perhaps 8-10 trips would be needed for the principal investigator and probably a similar amount for at least one other team participant. As a result, travel and hotel costs might be on the order of $20,000. However, the amount of travel costs will vary substantially depending on the identity of the selected decision-science participants. For example, the author of this Research Plan (R. Gregory) and the two peer reviewers (T. McDaniels & D. VonWinterfeldt) all have extensive experience in the conduct of the studies described here, but they also all live on the west coast. As confirmed by the many references that are made here to their work, other leading candidates who combine both research and applied experience in the decision sciences include both R. Clemen (Duke University) and B. Fischhoff (Carnegie Mellon University), who live substantially closer to the Tampa Bay area, as well as R. Keeney (University of Southern California).

6.0 References

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